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FORESTS AND WATER IN THE COLORADO RIVER BASIN

United States Forest Service

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

FORESTS AND WATER

IN THE COLORADO RIVER BASIN

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FORESTS AND WATER

IN THE COLORADO RIVER BASIN

Forest Land and Water Resources Relationships,

Problems and Programs

Forest Service
U. S. Department of Agriculture

Prepared in response to the letter of March 18, 1950,
to the Secretary of Agriculture from Leland Olds, Member
of President's Water Resources Policy Commission

June, 1950

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THE COLORADO RIVER BASIN

Description of the Basin

General

The Colorado River Basin comprises about one-twelfth of the United States. It drains a region 800 miles long and from 300 - 500 miles wide with a total area of 249,400 square miles or about 159,637,000 acres in Arizona, New Mexico, California, Nevada, Utah, Colorado and Wyoming, (Map 1). An additional 4000 square miles or 2,500,000 acres are located in Mexico.

The topography is greatly varied and complex, ranging from high rugged mountain ranges with peaks that exceed 14,000 feet in elevation to wide plateaus, from deep unscalable canyons to many gently sloping flat floored alluvial filled valleys and low desert lands only a few hundred feet above sea level.

The climate ranges from hot, arid desert lands receiving almost no precipitation, to humid mountains where annual precipitation ranges up to more than fifty inches. Drouth cycles, often lasting several years, occur at frequent intervals at which time flow often falls to but one-third or less of the average annual water yield. Summer rains sometimes contribute locally to stream flow but the bulk of the water comes from melting snow.

On at least eighty-five percent of the total area, precipitation is insufficient to permit the profitable production of cultivated crops or to provide perennial stream flow. As a result, the present agricultural and municipal developments are mostly located in the lower parts of the basin and are dependent upon stream flow or underground water, both of

(Over)

which have their source in the mountains and high plateaus.

The principal water producing portion is the high mountains and plateaus of the northern two-thirds of the basin, ranging from 8,000 to 14,000 feet in elevation where winter snows often exceed 100 inches and where the higher mountains are snow-capped eight to ten months of the year.

The mountain ranges of central and southern Arizona and New Mexico, which form the upper part of the watersheds of the Gila and Salt Rivers, though lower and somewhat less rugged than those in Utah, Colorado and Wyoming, are also important as water producing areas. The somewhat lower precipitation which they receive in the form of both rain and snow produces most of the stream flow and recharge of underground basins in that area.

This highly significant relation of the mountain areas to water supply is indicated by the following table.

Annual Water Yield (Inches per Acre)	Percent of Total Runoff	Percent of Total Area
40 inches or over	4	.2
30 - 40	11	1.2
20 - 30	20	1.5
12 - 20	35	6.6
5 - 10	15	5.5
Less than 5	17	85.0
	100	100

Life zones range upward from the dry, hot, sparsely vegetated desert to alpine meadows and naturally barren rocky peaks. They include the following major vegetative types:

Vegetative Type	Acres	% of Basin
Conifer forests	21,600,000	13.5
Woodlands	36,500,000	23.0
Mountain brush	14,600,000	9.0
Desert and semi-desert shrub	57,600,000	36.0
Grasslands	24,000,000	15.0
Cultivated	3,600,000*	2.3
Other	1,737,000	1.2
Total	159,637,000	100

*Of the 3,600,000 acres of cultivated land about eighty percent is irrigated.

Reliable information on all land ownership is not readily obtainable but federal lands comprise about seventy percent of the total. These are distributed as follows:

Agency	Acres	% of Basin
National Forests	28,460,000	18
Indian lands	27,300,000	17
National Parks & Monuments	3,700,000	2.3
Bureau of Land Management	46,000,000	29

Additional smaller areas in Federal ownership include Bureau of Reclamation withdrawals, military reservations, etc. There are about 48,000,000 acres in state and private ownership combined.

Present population estimated to be 918,000 is concentrated in the lower lying areas where level, arable lands have encouraged irrigation and urban development.

Nature and Importance of Water Use

Basically the economy depends upon water and the maximum perpetuation of its beneficial use for domestic and industrial consumption, irrigation and hydroelectric power. Resources of timber, forage, recreation and wildlife from the water producing lands also depends upon infiltration of precipitation into the soil and naturally regulated stream flow.

The Colorado and its tributaries are the main source of water for 2,250,000 acres of irrigated lands in the basin proper and an additional 416,000 acres in the Salton Sea basin in Sourthern California. These lands are used for the intensive production of high value crops, the income from which is currently estimated to be about $153,000,000 annually. In addition, about 184,000 acre feet of water are annually exported to other basins in Utah and Colorado for irrigation and power generation. Water resources of the Colorado are also of great value to some three million people of Southern California who annually import 63,000 acre feet through the Los Angeles aqueduct for domestic and industrial use and irrigation.

Over fifty percent of all the electric power used in the basin and the thickly populated metropolitan areas and industrial plants of Southern California is derived for hydroelectric plants on the Colorado River System which in 1943 had a capacity of 1,324,000 K.W.

Water, rather than good arable land, is already limiting the production of cultivated crops. It also limits municipal and industrial growth. Cities such as Tucson, Phoenix, Los Angeles and San Diego cannot long continue to increase in population and industry unless present water and power supplies are augmented. Realization of potential industrie=

such as the oil shale of Colorado, Wyoming and Utah and the processing of pulpwood will require large quantities of water. Considerable pressure is also being exerted for increasing the exportation of water to eastern Colorado and central Utah.

For all of these anticipated needs the Colorado River systems appear to be the only feasible source and additional projects have been proposed at a cost of several billion dollars which would fully utilize all of the water now available for use.

Relations of Forest and Range Lands to the Economy of the Basin

The bulk of the water supply originates on the forests and forest range lands of the humid mountains which annually yield from ten to upwards of forty inches of runoff. While these lands occupy only about fifteen percent of the area, they produce approximately eighty-three percent of the water supply. In addition, they exert important protective and regulatory influence on stream flow.

The twenty-eight national forests represented in the basin occupy most of the high water yielding areas and produce a major part of the water. For example, ninety percent of the 12,000,000 acre feet of annual flow in the Colorado State portion of the basin originates within the boundaries of the national forests of that state. This highly significant relationship of the national forests to water supply is further illustrated by Map 2.

While the most valuable product of the forest and range lands is water, other resources furnished by them contribute much to the wealth and stability of the basin and form a substantial part of the total resources of the nation. This is true of lands in all ownership but in the absence of much factual data concerning them, lands other than the national

forests and State and privately owned lands are discussed only in general term

Within the national forests there are approximately 7,433,000 acres of federally owned commercial timberlands located in the high water-yielding zone. They support a timber stand estimated at 34,200,000 M feed B.M. In addition, about 3,000,000 acres of forest land has been set aside and reserved as municipal watersheds, experimental areas and wilderness areas.

Forest lands in Indian reservations, contain roughly one-third as much volume and comprise about one-third as much acreage as are in the national forests. Other forested lands under state, county, municipal and private ownership occupy 6,123,500 acres of which about 3,000,000 acres are commercial timber.

Production of unfinished lumber in the basin is in rough balance with consumption and locally is very important. For a number of communities timber harvesting and manufacture are the chief sources of income.

The pinyon pine, juniper and oak woodlands, contribute fence posts, poles, mine props, rail ties and fuel wood in substantial amounts.

By far the largest portion of the basin is classed as range land and varies in nature from alpine meadows of the mountains to the valleys of the hot deserts. Roughly 134,500,000 acres, or eighty-five percent of the total area including 23,081,000 acres of national forest lands are grazed by domestic livestock and game animals.

The value of livestock products plus the services the enterprise supports, amounts to $154,000,000 annually. This makes stock-raising the leading agricultural pursuit. Seasonal use of the various physio-

graphic parts of the basin links mountains, foothills, and valleys, of all ownerships, in an interrelation of vital importance to the livestock industry.

The national forests are especially important because they supply the much sought after summer range. At the present time they furnish summer grazing for 246,600 cattle and horses and 1,135,000 sheep. In addition to the livestock, over 400,000 deer, elk and antelope graze the national forests. Although demand for grazing on national forests has been most acute, lands of all ownerships have felt the impact of the grazing pressure.

The Colorado Basin, virtually limitless in potential recreational opportunities, includes high alpine scenery, dark conifer forests, sunny mountain meadows, mountain lakes and streams, and endless expanses of desert lands carved by geologic forces into fantastic forms.

In the upper reaches of the watershed, large tracts, totaling about 3,000,000 acres of rough rugged mountains, have been set aside and are being preserved in their natural condition. These wilderness areas are among the highest water yielding lands and their preservation in relatively undistrubed condition guarantees continuation of their water producing and regulating functions.

Recreation is recognized as one of the important benefits which the public obtains from wild lands and many facilities have been provided especially by the Forest Service and the Park Service for this purpose.

In addition to the large number of visitors to the National Parks and Monuments, 3,000,000 people visited the National Forests in 1949

and the money spent by these tourists provided an important income to numerous communities and employment to thousands of people.

Wildlife provides outdoor sport and recreation to residents and visitors. It is also a major source of income through services provided to visiting sportsmen.

The big game population is largely dependent on National Forests and other associated and intermingled lands for summer range. These herds are estimated to be 363,000 deer, 45,000 elk, 500 moose, 7000 antelope, 5500 bear, 1500 bighorn sheep, and 14,000 peccary. The hunting of these animals yields about 5,600 tons of meat annually. Game fishing is available in the 8500 miles of stream and 83,500 acres of lake water of the National Forests. It is one of the most popular of outdoor sports and each year thousands of residents and visitors ply the streams and lakes of the mountainous areas with rod and reel.

Problems of the Forest and Range Lands

Water and Sediment Problems

The present and future demands for the water of the Colorado River require delivery of the water from distant mountain lands in sustained, regulated flow of usable quality. This makes it necessary to have elaborate systems of reservoir impoundments and extensive distribution systems. Several hundred have already been constructed with a total capacity of about 37,500,000 acre feet and costing millions of dollars. Proposed plans contemplate additional structures and enlargement of present facilities at a cost of several billion dollars.

In order to fully utilize the waters of the Colorado River for irrigation, power and industrial purposes, a great and complex system of storage and diversion works is necessary because of the wide fluctuations in

stream flow, both seasonally and annually. For example, the amount of virgin flow has varied from a minimum of about 5,000,000 to a maximum of 25,000,000 acre feet with the average annual flow being 17,300,000 acre feet. The effective life of the storage structures, those now operating and those projected for the future, is seriously threatened by the heavy load of sediment carried by the river — sediment that in part is the result of misuse of the watershed lands. No other large drainage in the United States has a higher rate of sediment production than the Colorado River. The ~~167~~ 107,000,000 acres above Hoover Dam produces 0.75 acre feet per square mile per year. A much higher rate has been measured or calculated from individual tributaries. This is shown by Map 3.

The seriousness of this sedimentation problem is brought sharply into focus by the fact that 125,000 acre feet of sediment eroded from the watershed is being deposited each year in Lake Meade.

The sediment carried by the Colorado River is in part normal; the result of so called geologic erosion. The presence of easily eroded rock formations in the basin and steep slopes on which a plant cover has never been sufficiently dense to protect the soil during high intensity storms, gives this basin an unusually high geologic rate of sediment production. The severity and extent of erosion today and the consequent sediment load of the river, however, are greatly increased over the geological norm because of unwise use of the basin lands, principally range lands.

At present, the bulk of the damaging sediments are coming from the lower slopes and the alluvium filled tributary valleys below the boundaries of the national forests. Here the vicissitudes of climate, lower

normal density of plant cover, higher proportion of easily erodible soil and a long history of severe use by livestock have resulted in widespread overgrazing and accelerated erosion.

In contrast to the heavily silt laden streams of the lower elevations, most of those draining from national forest lands are clear denoting general soil stability. There are, however, notable exeptions. Some streams are subject to frequent floods from torrential storms and carry abnormal amounts of sediment to the main drainage. Here, as also with the much more seriously deteriorated Indian and public domain lands, the unsatisfactory watershed conditions are due, for the most part, to overgrazing and secondarily to fires and improper logging practices.

Although the soils of the mountain slopes and high plateaus are still stable, for the most part, the comparatively deep mantle on them, held in balance by the presence of a protective plant cover, constitutes a great sediment potential which if released by plant depletion could increase sediment loads tremendously.

The objectives of management of all forest and range lands in the basin should be to stabilize eroding soils and to protect and use forage and timber resources which are still in satisfactory condition in such a manner that they will continue to hold the soil in place and favorably influence water yields.

Water consumption by cottonwood, willow and salt cedars, that have in modern times spread along most of the channels in the basin and become particularly abundant back of reservoirs' flowage areas, amounts to many thousand acre feet annually — a serious loss in a water deficiency area. Salt cedar growth in the low portion of the stream is reducing channel capacity and increasing flood frequency and severity.

Eradication of salt cedar is most needed on large areas of flood plain lands and the delta areas above reservoirs to reduce transpiration losses and to clear flood ways. This vegetal growth, however, is not all bad. In some places it is helping to stabilize channel banks and is lessening sedimentation in reservoirs. The protective functions of this vegetation should be considered in planning any eradication program.

Grazing Problems

The principal problems of the grazing enterprise on the national forests are: To adjust grazing use to the capacity of the ranges and to increase forage production.

Grazing began in this basin with the Spanish colonization of the Salt and Gila River valleys in the early eighteenth century and by Anglo-Saxons in the Upper Colorado about 1850. By 1890, essentially all of the accessible areas were being heavily used and many of them were seriously overgrazed. The more abundant forage and the perennial streams of the headwater areas, lands now in the national forests, were much in demand by the steadily expanding livestock industry, which resulted in extensive overgrazing and widespread erosion.

These destructive practices continued unchecked until shortly after the turn of the century, when the national forests were created. At the outset it was recognized that overuse was directly responsible for accelerated erosion, for increased frequency of floods, and for reduced forage production; and a program was initiated to bring livestock use into balance with grazing capacity. These pioneer programs were handicapped by the lack of technical information of the relationships of plant cover

to soil stability and water supply. Also more progress would have been made had the Forest Service been able to put into effect more completely and with greater dispatch the remedial measures known to be needed. Then, too, the program received a setback during World War I when additional livestock were permitted on some of the already overtaxed national-forest ranges in the hope that meat supplies would be increased.

The large acreage of public-domain lands making up 29 percent of the basin area was not placed under administration until 1934. These lands are mostly still overgrazed, and erosion is common. Progress in rehabilitation made to date does not give much promise for early restoration of the productive capacity or of the control of erosion.

Most of the privately owned and State-owned range lands have been similarly misused, and on them occur some of the most glaring examples of land abuse.

To restore the productive and protective functions of the depleted range lands will require not only an adjustment in use but also artificial revegetation of some of the most critical areas. To check the erosion occurring in mountain meadows and in the channeled valleys will in many instances necessitate a combination of revegetation and engineering structures. Although the general measures necessary for range rehabilitation are known, much more information on techniques and procedures are needed to assure complete success of the program. An accelerated research program for the basin is one of the urgent requirements.

Timber Problems

Timberland problems are most acute on lands in State and private ownership. Many of them, located in the high-water-yielding zone, have been

too heavily cut over, burned, and grazed. A substantial part of the lands in this ownership has been cut over generally without regard to the production of future forest crops or the requirements for watershed protection. Most of the private owners are interested chiefly in the first crop of timber and subsequent grazing use of their timberlands. There seems to be little prospect of realizing maximum yields of usable water and sustained production of timber from these lands under private ownership. A program of Federal acquisition to bring under control the most critical of these lands, both within the boundaries of the national forests and other important watersheds, would be desirable.

In the pinon-juniper woodlands, the cutting of fence posts, poles, mine props, and fuel wood is locally important. But here again little has been done on private lands to assure future wood products. Most of the juniper-pinon lands are overgrazed and the source of much sediment.

Fire hazards have increased in the commercial timberlands on national forests because slash from logging is left on the ground for silvicultural and watershed purposes; dense stands of young trees have been established because of increased protection; and greater use of the forests by the public is being made. This situation calls for intensification of the fire-protection program.

Bark beetles frequently build up to epidemic proportions in the timberlands of the northern half of the basin. One such attack now raging in Colorado has killed the mature timber on thousands of acres, and unless it is soon stopped there is a possibility that all merchantable Engelmann spruce in the basin may be destroyed. Where these attacks strike operable stands, management plans are upset, cutting cycles are disrupted, large amounts of merchantable timber is lost, fire hazard is

greatly increased, and watershed functions are damaged.

Recreation Problems

Recreation possibilities in the national forests are almost limitless, but to make them available to the people more facilities and more adequate maintenance are needed. Most of the forest recreation grounds are seriously overcrowded. In some places satisfactory sanitation standards are not being maintained, and the threat of pollution of water used downstream is serious. The danger of fire is increasing because of the overflow from crowded grounds into surrounding undeveloped areas. The vegetation in campgrounds and along stream banks within or adjoining the grounds is in many places already seriously damaged. Very limited funds have been available for maintenance and supervision, and most of the campgrounds and picnic areas are badly in need of extensive repair and reconstruction. Many such areas are partially unusable because it has not been possible to keep them in a proper state of repair and provide the necessary custodial services.

Wildlife Problems

Game animals, especially deer and elk, present a difficult problem of management which is complicated by their migration from foothills or desert lands where they winter to high mountains for summer range. Over-populations have resulted where refuges, buck laws, and other restrictions on the take have been retained over too long a period. Where this has happened big game herds have seriously depleted the vegetative cover and in local areas of concentrations have impaired watersheds by trampling and compaction of soils.

There are about 60 problem herds of deer and elk in the basin, and others are building up to threatening size. In many areas management of

problem herds is made difficult because of rough country, dense cover, remoteness from roads and hunting population, and difficulty is securing full agreement on conditions and management principles with sportsmen, State game departments, livestock operators, private land owners, and Federal agencies. Thus the agencies responsible for wildlife management are commonly prevented from applying desirable programs because of a lack of public understanding and support.

Man-caused changes during the past half century have depleted and destroyed the fishing in many streams. This has been accompanied by increased numbers of fishermen who have imposed fishing pressure beyond the present ability of the streams to provide fish. Fish cultural programs have not met the problem of providing increased fishing to meet present demands. Abuse of watershed lands by overgrazing and fire has introduced damaging changes in the flow of many streams. Accelerated erosion, heightened flood peaks, and the destruction of streambank vegetation has caused additional fish losses. Some streams have been ruined for fishing by floods, erosion, and mining refuse. Elsewhere the construction of upstream water storage reservoirs without provision for the adequate release of water during the low-flow period of the summer months has dried up the streams to the extent that fishing has been damaged.

Interrelationships and Broad Problems

Although much has already been invested and greater expenditures for reservoirs, water-distributing systems, and hydroelectric power plants proposed, agencies responsible for planning and construction of these investments have given comparatively little attention to land conditions or the possibility of perpetuating and enhancing the value of

water developments through stabilization programs on the lands above the reservoirs.

There has been too little recognition of the interrelationship of all of the grazing lands and insufficient appreciation of the need for restoring and maintaining an adequate plant cover on all lands, both from the standpoint of protecting water supply and increasing the forage resource.

Many water users, livestock producers, and wildlife and recreation interests have failed to give proper weight to resources other than those in which they are particularly interested, with the result that conflicts have arisen between groups of users and land managers. This has handicapped improvement programs, especially those dealing with recreation, wildlife, and watershed restoration and protection.

Some State agencies and many private landowners whose lands are in critical condition show little interest in the public values attached to their lands. Such lands frequently contain hazards which threated adjoining Federal lands. Many private owners are financially unable to install and maintain remedial treatment necessary to protect downstream values. Where such ownership is intermingled with other lands, the full application of watershed protection and improvement programs is seriously handicapped.

The people as a whole have not been adequately informed of the multiple uses to which all wild lands should be devoted. As a result there is a considerable amount of lethargy concerning the seriousness of present conditions and the need for intensified action.

Factual information on the effects of present undesirable conditions

and the basic knowledge and technical skills required to fully accomplish restoration is far short of that which will be needed to accomplish the goal of rehabilitation, restoration, and maximum development of resources.

Special Problems

1. The necessary adjustment in numbers of livestock permitted to graze on national-forest land is being vigorously resisted by the national livestock associations and some local and state livestock groups. Lack of appreciation of the interrelated nature of grazing use by some add to the problem. This situation makes the job of reducing livestock use to grazing capacity very difficult. It also retards the application of other remedial treatment to depleted watershed lands and complicates cooperative relations with many other users of the national forests.

Immediate, satisfactory solution of this important problem will not be easy. Among other things it will require more widespread public acceptance of conservation principles and increased recognition of the importance and value of other uses of national-forest lands.

2. On the public and private range lands there are many examples of competitive use between livestock and big game on overgrazed range. The difficulties which arise because of this are mostly due to resistance by many livestock operators to the use of forage by big game and opposition by hunters to reduction in game numbers to bring the latter in line with forage supply.

Solution of the livestock-big game conflict is difficult. The State game commissions, the Forest Service, and other public land-managing agencies must first secure basic facts to support their programs. After this is done the public and especially the wildlife and livestock groups

will need to be convinced through education and demonstration that programs proposed for the management of game are in the public interest.

3. The planning and construction of major reclamation and flood-control projects inside of adjacent to national forests have created numerous administrative problems. These consist chiefly of the destruction of physical improvements, impairment of services, and the accelerated erosion of stream channels as a result of transmountain water diversion. While some replacement of improvements has been made, they have often been inadequate to replace the services formerly supplied.

To meet this problem funds should be made available to the land-managing agency to plan required changes. Construction agencies should provide funds necessary to restore services, and project estimates should include recommendations for the appropriation of funds for maintenance.

4. The mining laws permit the alienation of public watershed lands irrespective of the effect of mining operations on the watershed or the public values involved. In addition the mining laws are subject to abuse and are often used to obtain control of land for other than mining purposes. On many claims other values such as timber exceed the value of minerals, but after the claim is patented these other resources may be disposed of or treated as the claimant desires. A solution to this would be to allow mineral extraction on a leasing basis the same as is now done for oil and gas under the Mineral Leasing Act.

5. Most of the reservoirs and other water-development projects have been constructed with too little attention to recreation use and demands. Few recreational facilities have been provided, and overcrowding with attendant unsanitary and unsafe conditions is common. Present

overcrowding on national forest lands could be relieved if the recreational potential of water development projects could be more fully realized. The situation could be relieved by full recognition of the recreational resources in the planning, construction, and operation of water-development projects. A significant part of such planning should be the acquisition or designation of sufficient areas around reservoirs to provide adequate room for recreational development. Moreover, planning of reservoirs should include consideration of diking off shallow runs to minimize water fluctuations when the main surface of the rervoir is changed by drawdown. Stabilizing of small water surfaces could be used to enhance recreational opportunities or to benefit wildlife.

6. In several parts of the basin, downstream water users are opposing watershed restoration programs because of their belief that to increase the present depleted vegetative cover on eroding lands will result in reduced water supplies downstream. These people generally admit the seriousness of sedimentation but propose to meet it by costly replacement reservoirs.

A more intensive research program is needed to establish factual data on the effect of vegetation of water yield. This should be supplemented by an educational program to acquaint the public with the pertinent facts. Other agencies engaged in water development should recognize this upstream need for water and make provision for such use.

7. A considerable acreage of state owned forest and range land is intermingled with federal lands within national forest boundaries. In Arizona, New Mexico, and utah grazing and timber cutting are usually handled on a lease basis with little supervision. As a result there has been severe depletion of the vegetative cover on many tracts. While

much good can be done by consolidation of these intermingled lands through exchange, a better appreciation of watershed values by state officials is needed. Cooperative arrangements for management by the Forest Service, now quite limited, would bring about more efficient and effective use and should be expanded.

8. Arizona, New Mexico, and Wyoming have not enacted enabling legislation providing for cooperative fire control authorized by the Clarke-McNary Act. Of these, only Wyoming has endorsed cooperative tree planting under this same act. This situation prevents private land owners from obtaining the assistance they should receive in controlling fire and replanting unstocked timber lands.

In addition to public assistance in fire control, tree planting and other services to landowners, there is need for public regulation of cutting practices to insure that privately owned forest lands are kept reasonably productive.

9. Public ownership of certain high value watershed lands appears necessary if the needed restorative measures are to be installed and properly maintained. In many cases depletion has progressed to the point where the private owners are unable to bear the cost of rehabilitation. Others are unwilling to install costly measures needed to reduce flood and sedimentation threats to downstream developments. Some hesitate to do expensive reforestation or range improvement where benefits will not be realized for many years. A few counties have opposed further Federal acquisition in the belief that it will reduce their income. Only three of the twenty-eight national forests may apply receipts to the purchase of land, Arizona, New Mexico, Colorado and Wyoming have not passed permiss-

ive legislation for acquisition of land under the Weeks Law. These enabling legislative actions are needed. In addition it may be desirable to modify legislation providing for lieu payments to counties for federal lands within the counties.

Early completion and approval by Congress of the watershed survey report by the Department of Agriculture may also provide Federal authorization and funds for urgently needed conversions to public ownership.

10. There is considerable variation in the economic procedure for arriving at cost-benefit rates used by the several Federal agencies engaged in water developments and flood control. Some fail to include or adequately consider long-term public benefits. As a result there is insufficient appreciation by some agencies of the need for early action to prevent future damages. In some cases little concern has been shown about the possibility that key water developments may be destroyed by siltation within the next 200 years unless immediate preventative measures are initiated.

Methods and procedures for evaluating future benefits, especially those of public nature, should be unified and correlated so that watershed improvement programs can be more effectively coordinated with reclamation and flood control projects.

11. Absence of many kinds of basic data, commonly used as working tools, hinder and delay national forest and research programs. Many gaps in knowledge exist among the more important of which are: lack of full coverage of aerial photography, overall surveys and inventories of water, forests and range, soils surveys of wild lands, measurements of precipitation, snow accumulation, sediment production, topographic and planimetric maps, geology maps.

The collection and compilation of this data should be expedited.

Present Program and Additional Needs.

Needs on Forest and Range Lands.

A number of major jobs confront land managing agencies and private land owners on the forest and range lands in this basin. Most important of these are the following: (a) continued production of maximum amounts of usable water; (b) use of timber, forage, recreation and wildlife resources so as to secure sustained, optimum returns from each without impairing the water-producing function of the lands; (c) restoration and repair of denuded lands where cover has been destroyed or damaged and erosion has been accelerated.

After vegetative cover is restored to denuded lands and accelerated erosion is checked, under continued good management the role of the forest and range lands in producing usable water can be maintained indefinitely. However, the halting of further decline and the application of restorative measures has progressed at too slow a pace to guarantee restabilization of injured lands before further damages result from sedimentation of reservoirs, increased frequency and heights of floods and polluted water supply. At the same time, maximum returns from resources are not being obtained. Intensification and acceleration of many measures now employed are necessary if these goals are to be achieved.

While this situation applies to forest and range lands of all ownerships, lack of information and space permits only general discussion of current accomplishments and anticipated needs on State and private lands and those administered by the several agencies of the Department of the Interior.

It is assumed that these lands will require treatment similar to that for National Forests and to an equal or greater degree.

Regular Activities on National Forest Lands

The national forest program has as its objective the management and use of the forests and ranges in ways which will produce the maximum benefits from all resources including w ter. National forest management constantly strives to do this as authority, funds and manpower permit but much remains to be done.

Operations which specifically apply to or are closely related to water use and development are outlined in the following paragraphs.

Grazing use and season of use of range lands is adjusted to grazing capacity as required by condition and trend of the land in individual grazing permits. This is supplemented by other aids including control of trespassing livestock, range fences, and watering facilities and the control of noxious weeds and plants. While much has been accomplished, about one-half of the ranges are overstocked and current grazing use must be further reduced or temporarily excluded until range plants recover. More range improvements, including about 8,400 miles of range fences, 2,100 well and spring developments and 1,800 stock ponds, will aid range improvement and utilization.

Restoration of vegetative cover and greater production of desirable forage grasses can be speeded up but less than ten percent of the suitable lands have been treated and some 1,300,000 acres remain to be reseeded.

Complementary measures, mostly of a minor structural nature, are needed on seriously eroded land to aid in bringing channel erosion and soil loss under control until vegetation can again exert its stabilizing influ-

ence. A limited amount of work was done in the 1930's in cooperation with the Civilian Conservation Corps but such work remains to be done on approximately 990,000 acres.

On municipal watersheds and other slopes where flood and erosion hazards are particularly high, the preservation of maximum watershed stability is paramount to all other uses. Under such conditions, livestock should be excluded and game animals closely controlled. This is being accomplished in a limited way as urgent situations develop but should be expanded as demanded by the public and as control of the watershed lands can be obtained through acquisition, exchange or cooperative agreements with other public land owners.

Range surveys which are basic for the preparation of grazing management plans are made as funds permit but they need to be completed and brought up to date.

Although there is constant effort to keep users of the range and other interested groups informed, there is need to more fully acquaint these epople of the present condition of the range, its relation to other uses and values, the productive potential and steps which will be required to meet and achieve it.

Public acquisition of badly depleted watershed lands is essential in many places. It is also needed to provide additional recreational areas and game ranges. At present, it is almost entirely limited to that which can be obtained through exchange. Altogether about 890,000 acres should be acquired but less than 30,000 acres are now being acquired annually. Stepping up of this part of the program will require appropriate legislation by the states where it is now lacking, approval of purchase

units as provided by the Weeks law and passage of receipts acts for a larger number of the forests.

Protection is afforded to national forest lands through the control of fire. In spite of present efforts, the annual burn has increased in recent years in Arizona and New Mexico. To meet this threat caused by increased fire hazards will require additional capital investments in roads, communication systems, lookouts and fire fighting equipment. Epidemic insect attacks are combatted as they occur and as funds permit but that now raging in Colorado poses a threat which must be met by intensified and extended control measures.

Present timber harvest in the national forests amounts to about 246 M board feet; this is about one-half of the potential cut from these lands. As demand increases more of this potential can be realized but it will require more access roads, forest surveys, and additional manpower to plan and supervise harvesting operations and post-harvest treatment of the logged area.

The recent provisional award for the sale of 4,565,000 cords of pulpwood in Colorado promises to open up a new timber harvesting program which may expand to extensive areas now largely unused. This will impose additional burdens and problems on management to insure that watershed values on these high water yield lands will not be damaged.

Although there is a considerable area of cut over and burned timber lands not now satisfactorily restocked, no replanting of forest trees is being done largely due to lack of funds and knowledge to do such work. Some 217,000 acres of timberland need to be replanted.

At present, the bulk of road and trail funds are utilized for maintenance and on many roads additional drainage improvements are needed to check runoff and erosion. The public construction of about 7,600 miles of access roads will be required as demand for increased timber harvest mounts. These roads will also make it possible to provide more adequate protection from fire and insect pests, reduce grazing damage done by the trailing of livestock, and will open new areas to vacationists, hunters, and fishermen.

Recreational use of the national forests has been encouraged by the construction of 900 developed areas. Currently these facilities are badly overcrowded and in need of reconstruction and repair. Within the limits of funds and manpower available, their use is encouraged and protected by garbage disposal; policing of grounds; protection from fire; maintenance of water supply, sanitary facilities, roads, trials, and bridges. Structural and layout plans for expansion of recreational facilities are prepared as construction funds become available.

Many jobs need to be done in order to correct current problems caused by overcrowded recreational facilities and to care for the anticipated increase, and to protect downstream water users from pollution and to reduce the fire hazard. Specific requirements of major importence are:
(a) sufficient funds to repair, maintain and supervise present units:
(b) increased funds for the construction of additional facilities;
(c) additional personnel to plan additional developments and supervise construction and later operation.

Some water rights or the right to use water should be acquired in order to permit the use of water for upstream recreational developments

and to improve wildlife habitat. This may also be necessary to provide for such improvements as the irrigation of mountain meadows to increase forage supplies and lessen grazing pressure on overgrazed slopes.

Currently the realization of wildlife resource values is attempted by cooperating with state game departments and other federal agencies in the preparation of management plans for game animals, fur bearers, upland game birds and fish. This includes technical assistance in obtaining census data, information on watershed condition of game ranges, forage conditions, disease, annual harvest, condition of animals and other information pertinent to the problem. State game officials and other agencies are assisted in analyzing data and in preparing recommendations on hunting seasons, bag limits, and law enforcement.

Future management of the wildlife resource is largely dependent on a better informed public regarding the impact of poor management on watershed functions of mountain land, downstream effects and the adverse effects on the herd itself. Accomplishing these things will require adequate funds for the Forest Service to participate actively with the states, other federal agencies, and organized wildlife groups in a fully coordinated wildlife management program. This includes more technical personnel for the collection of basic data on populations, forage conditions, disease and winter losses, annual harvest and other pertinent data.

Certain important game winter ranges are badly depleted and the replanting and reseeding of game food species is needed.

While many of the other measures will improve fishing there is a need for some minor structures such as low water dams to further improve fish habitat.

The additional needs indicated above represent a marked increase in supervisory obligations. Planning and execution of the additional measures needed will require field personnel commensurate with the job to be done.

Present capital investments in national forest land now amount to $36,894,000. Annual recurrent costs of management and protection are $3,160,000. Accomplishment of the needed expanded program for full development of all resources, including necessary land acquisition and development of acquired lands, will require additional capital investment of $440,280,000. Annual recurrent expenditures needed to provide an acceptable standard of protection and management of national forest lands on the basis of existing improvements and facilities and the current volume of business are estimated at $4,678,000.

Cooperative Assistance on Non-Federal Lands

State and privately owned forests and woodlands include 6,124,000 acres of commercial timber intermingled with federal timber lands and a much larger acreage of pinon pine, juniper and oak mostly outside national forest boundaries.

Very little technical assistance has been given to these non-federal operators. This is especially true in Arizona, New Mexico and Wyoming, who do not have state forestry organizations. In New Mexico, some aid has been supplied on state land through the preparation of timber cutting plans following state specifications.

Non-federal lands within national forest boundaries receive very spotted fire protection. It has not yet been possible to effectively work out cooperative arrangements with the states for fire control on a cost-sharing basis. Cooperative assistance in fire control and tree planting

on non-federal lands as authorized by the Clarke-McNary Act is limited. This is in part due to failure of Arizona, New Mexico, and Wyoming to authorize state participation and provide matching funds for fire control. Similar authorizations for cooperative assistance in tree planting are lacking in Arizona and New Mexico.

Currently cooperative fire control for the protection of both commercial timber and important watersheds is in effect on 6,500,000 acres. This should be extended to some 2,700,000 additional acres for watershed protection.

No State or Federally operated tree nurseries for the production of planting stock are located in the basin and little has been accomplished to aid private operators in replanting denuded forest lands. Current distribution of low cost planting stock to farmers is confined almost entirely to furnishing stock for shelterbelts and windbreaks on irrigated lands. This part of the program should be expanded to provide assistance to private owners of forest lands which need to be replanted for watershed protection.

There is a need in the basin, and nation-wide, for improvement of cutting and other forest practices on private lands. Every effort should be made to bring this about by education and other means of encouraging voluntary corrective action by landowners and operators. But to keep private forest lands in reasonably productive condition, there is need for a system of public regulation to reinforce the means presently available. The individual States should continue to have opportunity to enact and administer regulatory laws. But there should be basic Federal legislation to assure a consistent pattern and effective action within a reasonable time.

Present federal expenditures for cooperative assistance in fire control and tree planting amount to but $14,000 annually. State contributions total $31,000 annually. To meet the need which exists, the annual federal participation should be increased to about $105,000 for fire control and other protection and $85,000 for tree planting and technical assistance or a total of $190,000. A similar amount should be supplied by the states.

Supporting Investigations and Surveys

The main program of watershed research now under way in the basin is that of the Forest Service. It is now being carried out at 6 permanent locations in the basin supplemented by numerous field studies at temporary locations. The principal objective of this research program is the discovery and dissemination of factual information concerning methods of handling forest and range lands which will produce maximum yields of usable water, minimum yields of sediment, and maximum returns from other resources. In this capacity it serves all forests and range lands regardless of ownership.

Unfortunately investigation of the technical aspects of land management and its effect upon water supply and sedimentation has lagged far behind the rate at which multi-million dollar reservoirs and other water and power developments have been planned and constructed. Neither have investigations been adequate to provide answers to many other problems concerning the optimum use of timber, forage, wildlife and recreation resources. An expanded investigation program is needed to provide a sound technical base for the many untested practices and measures which must be applied.

The major types of studies or work projects now under way include:

1. Studies of soils with emphasis upon their relation to infiltration, mantle storage of water, and mantle stabilization.
2. Climatic relations, investigations of winds, temperature, snow accumulations and melting and summer storm phenomena.
3. Plant relations studies consisting of the determination of interception of precipitation and of evapo-transpiration losses.
4. Water relations studies to determine the effect of plant cover of varying kinds and conditions upon infiltration, surface runoff, and erosion. These particular studies also include investigation of the effect of land use and treatment upon stream flow behavior and sedimentation.
5. Studies to determine the most efficient and economical practices whereby the vegetative cover in forests, woodlands, and range lands can be restored or reinforced where damaged or destroyed by past use.
6. Studies to determine the proper criteria and specific practices which will permit the continued maximum harvest of timber products and forage compatible with wise and safe watershed protection.
7. Cooperative investigations with the states and the Fish and Wildlife Service of the big game problem including census, food habits, food supplies, harvest, biological aspects of management, and methods of increasing food supplies.

Current studies should be continued and intensified and others should be initiated so as to keep pace with increased development. The principal kinds of additional investigations needed are: Forest and range influences

studies of, (a) factors which affect the water cycle, (b) the use of water by various plants, (c) the soil stabilization value of various forest and range types (d) the effect of land use practices upon watershed behavior in the major physical sub-divisions of the basin.

The possibility that water yield may be increased by manipulation of forest cover needs to be exhaustively investigated.

Present information about the consumption of water by vegetation on mountain lands must be greatly augmented.

An inventory of the forest lands should be taken to provide (a) the extent and location of the principal forest types, (b) the volume of usable wood products (c) reliable estimates of growth and drain.

Forest management reserch needs to be materially expanded to give basic silvicultural answers and sound management practices for all of the major forest types in the basin. Timbered areas ravaged by insects need careful study to ascertain such things as: (a) how they should be logged, (b) how can they best be reforested, (c) what effects will the harvesting of them have upon water yields and erosion. Much more needs to be learned about proper methods of harvesting commercial timber lands in relation to maximum water yields and minimum sediment production.

It has been determined and demonstrated that vegetative cover can be restored and forage production increased by the reseeding of a large portion of the range lands of the basin. Similar studies should be carried out to fully explore the possibilities and practices required to expand this sort of treatment to the even larger but drier part of the basin.

Much remains to be found out about the management of range lands and of livestock and big game so as to restore adequate vegetative cover,

reduce erosion and increase forage supplies. This should include such things as: (a) systems of grazing, including intensity and seasons of use, utilization standards, and range forage supplements, (b) range condition and trend of major vegetative types (c) noxious plant control, (d) influence of rodents on range recovery and deterioration. Practical methods of eradicating or controlling juniper, sagebrush and mesquite which has invaded many thousands of acres of depleted range lands.

Little study has been given in this basin to fire control and related problems but the increased fire hazard which now exists emphasizes the need for investigations on fire behavior, fire danger rating, and improved fire control techniques.

Where erosion is advanced, restoration of vegetal cover on forest and range lands will not alone rehabitate the watershed, and more information is needed on erosion control structures.

In addition to its other research activities, the Forest Service has an active part in flood control surveys. These are conducted in cooperation with the Soil Conservation Service and other agencies of the Department of Agriculture with assistance from administrators of other federally owned lands. The surveys involve the examination of all lands within the sub-basin surveyed and the development of a recommended program of watershed improvement measures for the primary purpose of reducing the flood and sediment damages. Surveys have been completed on a total of 19,700,000 acres comprising the upper Gila River in Arizona and New Mexico, Queen Creek in Arizona and the Virgin River in Nevada, Utah and Arizona. This work should be expanded to include all of the lands of the basin.

Summary

The current annual expenditures for research investigations exclusive of flood control surveys are approximately $233,000.

To carry out investigations at a level which will provide the basic information to support expanded programs for rehabilitation, protection, development, and use of the resources of all the forest and range lands in the basin will require capital investments of about $4,301,000 and recurrent annual costs of $1,273,000.

Completion of the flood control survey for the whole basin will cost approximately $650,000.

Summary of Forest Service expenditures and additional needs.

The present Forest Service program on forest and range lands while of considerable size is far short of that required to achieve full realization of all of the benefits which these lands can and should produce.

These present expenditures and future needs are briefly summarized in the following table:

Major Forest Service activity	Non-recurrent capital investments	Annual or recurrent expenditures
	Amount (dollars)	Amount
Protection and management of National Forests		
Present Expenditures	38,894,000	3,160,000
Estimated Needs 1/	440,280,000	4,678,000 2/
Cooperative assistance to non-federal land owners		
Present expenditures	(prorated	14,000
Estimated Needs	(into (recurrent (costs	190,000
Research investigations		
Present expenditures	— 3/	233,000
Estimated needs	4,301,000	1,273,000

1/ Estimated needs are tentative, subject to revision, and should not be published.

2/ Estimated needs for the national forests are to provide an acceptable standard of protection and management based on existing improvements and facilities and current level of business.

3/ Not separable from national forest investments.

The Recommended Program Can Be Justified

Development needs and cost estimates were for the most part prepared from limited preliminary studies and ground surveys. It will, therefore, be recognized that they may be changed when it becomes possible to complete more detailed analysis.

Full accomplishment of the needed program will produce many benefits, some of which cannot be exactly measured at this time. Although water forms the limiting factor for future increase in population and industrial growth, there are few guides available which can be used to quantitatively evaluate the social values recognized to be of great consequence.

No claim is made that the program herein recommended will entirely remove the threat to present water use and further development, for normal geologic erosion and sediment production is high. However, there is ample reason to believe that erosion and sediment production, which has been brought about by man's use, can be greatly reduced if not altogether stopped thus prolonging the effective life of reservoirs and other related water developments which support most of the economy.

At the same time the things which need to be done to protect water supply and enhance its value will produce onsite benefits in the form of increased timber growth, more forage for livestock and big game, increased

opportunities for recreation, hunting and fishing. As an illustration, it has already been well demonstrated that restoration of vegetation on range lands either by reseeding or improved range management will increase harvestable forage many fold at the same time it is stabilizing the soil.

Additional indication of the ratio of costs to benefits is provided by the flood control surveys which have been completed on some 20,000,000 acres. The interdependent program of land treatment and structural recommended for the reduction of sediment and flood damages is quite similar to that herein proposed for the national forest lands and these surveys indicate that the benefits will be well in excess of the costs.

POLICY PROBLEMS AND RECOMMENDATIONS

The following recommendations are applicable not only to the Colorado River Basin but some also to other river basins. They were selected as being of particular significance to this basin.

1. Watershed management: Vegetative cover on this watershed helps to reduce floods, regulate stream flow and stabilize soil. Domestic, irrigation and industrial water supplies are all influenced tremendously by range and forest conditions of the basin.

In this basin about 80 percent of the water used for all purposes falls on the forest lands. Their management therefore assumes far greater importance than can be measured by the timber and forage they produce, the wildlife they harbor, and the recreation they afford.

Generally, the problems which these lands present arise from deterioration and destruction of the vegetal cover through lack of adequate protection and through mismanagement for other use. Fortunately, approximately 70 percent of these range and forest lands are in Federal ownership. This should facilitate restoration and proper management.

Watershed protection was the principal purpose in the creation of the national forest system. Yet aside from protection from fire, we have been more concerned with the development of timber, range, recreation, and wildlife resources than with water. Research is showing how range use and timber cutting can be coordinated with watershed protection. But we have only begun to understand the complex relationship involved and have made too little progress in applying measures to maintain watershed values, increase water yields, or rehabilitate damaged watersheds.

The value of the national forests as sources and conservers of water here and elsewhere should be recognized. Provision should be made for restoring protective cover by reseeding and other remedial treatment on the seriously deteriorated range lands. This should be supplemented by forest planting on other lands denuded by fires. Protection against fire, insects, and disease should be intensified. Commercial forest areas should be made accessible by road construction. Adequate provision should be made for integrated and coordinated development of all national forest resources, including necessary surveys and plans.

Programs for watershed management on national forests should be supplemented and supported by parallel plans for adjacent and intermingled lands. This is particularly important with respect to grazing districts, public domain, and Indian reservations, as well as to private range and forest lands.

Nearly 50 percent of the total area consists of range and forest lands under the administration of various agencies of the Department of Interior. The size of these areas indicates the necessity of providing for their restoration and maintenance along with the national forests.

Large blocks of watershed lands are in State ownership. In many instances they are managed with little apparent attention to their watershed values.

Lack of adequate watershed management has cost the people in this country millions of dollars. Good watershed management is essential to the life of much of the economic development based on our water resources. More than that, it is also important to the farm land and forest economy in the Colorado Basin.

2. Cooperative assistance in fire control and tree planting: Arizona, New Mexico, and Wyoming have not enacted legislation providing for the cooperative fire control authorized by Clarke-McNary Act. Of these only Wyoming has endorsed cooperative tree planting under this same act. This situation prevents private landowners from obtaining assistance they need in controlling fire and replanting unstocked timber lands.

3. Multiple use of forest lands: The multiple-use principle should have wide application in the management of watershed lands, especially those in public ownership. All the goods and services the forest can render should be developed under careful planning to protect and enhance watershed values. This multiple-use policy has guided national forest management, and sets it apart from private forest management.

Good watershed management rarely precludes other forest uses. Where damageable values downstream are high, soils unstable, and runoff problem serious, watershed protection may require foregoing one or all of the human uses to which the forests might otherwise be put. In most areas, the forests may yield timber products, provide forage for livestock and game, afford opportunities for recreation, and in other ways produce returns without serious detriment to the watershed. The nature and intensity of use should of course conform to requirements for soil and water flow stability.

Even on municipal watersheds it should seldom be necessary to exclude logging, grazing, or agricultural use except for critical areas such as those along reservoir margins and feeder streams.

The classification of lands with respect to priority of watershed values and their sensitivity to damage should be undertaken as needed to guide watershed management and use.

4. Watershed damage from overgrazing: Overgrazing on public and private range lands is a primary cause of the high rate of accelerated erosion and sedimentation now taking place. This problem is of critical importance because at least 85 percent of the area of the basin is grazed. The consequences of too heavy grazing include progressive deterioration of the vegetative cover and of soil resources, accompanied by accelerated surface runoff, erosion, and sedimentation.

Use of range lands by both domestic livestock and big game should be brought within carrying capacity of the ranges, and depleted range vegetation restored as rapidly as possible. These objectives should be included in national water policy as an essential means for bringing about good watershed conditions.

It is the policy on national forest ranges, at least, to adjust grazing to range capacity and to rehabilitate depleted ranges. Needed adjustment is being vigorously resisted by the national livestock associations and some local and State livestock groups. This makes the job of reducing grazing use very difficult. It also retards the application of other remedial measures and complicates cooperative relations with other users of the national forests. Greater public support for the efforts of the Forest Service is needed to make them fully effective.

5. Conflicts over the use of water by vegetation: Some downstream water users oppose watershed restoration because they believe that to increase the present depleted vegetative cover on eroding lands will result in reduced water supplies downstream. These people generally admit seriousness of sedimentation but propose to meet it by costly replacement reservoirs.

More intensive research is needed to establish factual data on the effect of vegetation on water yield. This should be supplemented by an educational program to acquaint the public with the pertinent facts.

6. Multiple-purpose water development: More effective and profitable use of the water resources may be possible by more careful analyses in the development of water using projects of all of the beneficial uses to which the water resources may be put. A related problem is that of coordinating watershed treatment programs with those of river development. This is desirable as an over-all policy, and is also needed project by project.

7. Public acquisition of critical watersheds: Public ownership of certain high-value watershed lands is necessary if needed restorative measures are to be installed and properly maintained. In many cases depletion has progressed to the point where private owners are unable or unwilling to bear the cost of rehabilitation.

There should be Federal authority in flood control programs to acquire land of any sort above reservoir projects when necessary to prevent damaging sedimentation. Such lands should be added to the national forests whenever they can be effectively administered as such.

8. Financial contributions to local government: Payments to local government on account of Federal forest and range land should be on a uniform and reasonable percentage of fair value. This ratio should be less than the ratio of property taxes paid to fair value because of contributions in kind, such as forest fire protection furnished by the Federal Government. The ratio of three-quarters of one percent of fair value is recommended as the standard. Existing practice has no consistent policy basis. For example, grazing districts contribute 50 percent of gross receipts; national forests contribute 25 percent.

9. Forest regulation: There is a nation-wide need for establishment of a system of public regulation of cutting and other forest practices that will stop forest destruction on private forest lands and keep them reasonably productive.

The States should continue to have opportunity to enact and administer adequate regulatory laws. However, in order to assure a consistent pattern - nation-wide and in a reasonable time - a basic Federal law is needed. This measure would complement public aids and technical services to private owners and educational efforts which should be continued and strengthened.

The Federal legislation should establish standards as a guide for local forest practices and authorize Federal financial assistance to States which enact and administer regulatory laws consistent with the Federal requirements. It should also provide for Federal administration in States which request it or which, after a reasonable period, fail to put such regulation into effect.

The need for public regulation of timber cutting is exemplified by conditions on private lands in the Colorado River Basin. A survey made in 1945 of the character of timber cutting on commercial private lands showed that most of it in the basin was poor or destructive. As a result of past poor practices and fire, a large proportion of the private land is non-stocked or poorly stocked with seedlings or saplings.

The State of New Mexico has had a forest practices act since 1939. However, the act is seriously deficient in important respects, and facilities for enforcement are virtually lacking.

10. Disruption of national forest resource services and facilities: Reservoir project planning should take realistic account of replacement of national forest facilities and services destroyed or made useless by reservoir construction. Consideration should also be given existing and potential use of land and resources. Replacement of facilities should be on the basis of equal utility not merely in kind. Reservoir planning should be integrated with existing land and resource development plans so

that reservoir benefits may not be at the unrecompensed expense of other resource benefits, such as sustained yield of private and public timber.

The act authorizing a Federal agency to build a dam which would impair national forest administration and services should include authorization to expend as a part of the project cost such sums as the Secretary of Agriculture considers necessary to correct the impacts on national forest resources and services resulting from the reservoir developments, including plans and surveys by the Secretary of Agriculture.

11. Revision of mining laws: Federal mining laws should be revised to provide for regulation of mining operations on Federal lands to control erosion and sedimentation of streams. This would require either: (1) Revision of the mining laws to institute the leasing system covering all minerals or some effective alternative; or (2) withdrawal of critical watersheds from damaging mining development.

12. Withdrawal of national forest lands: No disposition of national forest lands for reclamation or other purposes should be made, and no leases, licenses, or easements affecting such lands should be granted without the concurrence of the Secretary of Agriculture.

Under certain existing statutes, other Federal departments possess an overriding authority over national forest lands for certain definite purposes. For example, the Reclamation Act gives the Secretary of Interior authority to withdraw national forest lands for first form reclamation withdrawals and to construct and operate reclamation works thereon. The Secretary of Agriculture has no authority to disapprove such action, regardless of possible deleterious effect on national forest administration or management.

Several other acts give the Secretary of Interior authority to grant easements over national forest lands. There is no statutory provision for approval or disapproval of the Secretary of Agriculture.

13. Preservation of wilderness areas: The preservation of primitive country for enjoyment of wilderness recreation is an established policy of the Forest Service in administering the national forests. Improvements are limited to trails, essential protection developments and sanitary improvements at camp spots where necessary.

Two threats to this program, which are presently beyond the control of the Forest Service and the Department of Agriculture, have been mentioned in two proceeding sections. First, since these areas are in lands withdrawn from the public domain for national forest purposes, they are subject to mineral location under the U. S. Mining Laws. Second, water impoundments may be planned for development on national forest lands, including wilderness areas, without consent of the Secretary of Agriculture.

Authority should be lodged in the Secretary of Agriculture to prevent these threats when the values for wilderness recreation outweigh benefits that might be derived from mining development or water impoundment. This would require: (1) revision of mining laws; (2) provision for full consideration of conservation values before a water development project is planned.

14. Reservoir operations in relation to recreation and wildlife: Reservoir operations should be planned to maintain, insofar as possible, suitable water levels for recreation and wildlife. Excessive drawdown during the recreational season creates difficulties in maintaining an attractive and convenient shoreline. It also precludes suitable marsh habitat for wildlife and fur-bearers. Fish life is adversely affected. Diking of shallow reservoir arms could provide marsh habitat or recreational water surfaces little affected by drawdown of the reservoir. Releases of water below the dams should be controlled to maintain or improve fish habitat and provide for recreational development insofar as practicable.

Avoidance of excessive drawdown depends upon purpose of the dam. If used for irrigation it may be necessary to relinquish attempts at recreational use unless a series of dams is involved. In the latter case, coordinated control of drawdown may preserve the recreational values. Dams planned for the Colorado Basin are numerous and to a considerable extent interrelated and the entire system may later come under one master control. This should provide opportunity for planning adequately for recreational developments.

15. Public acquisition of land at reservoirs for recreation: A legitimate portion of reservoir costs should be allocated to development of recreation, including land purchase. The acquisition of land for reservoir development should include sufficient area above maximum water level to provide for full public development of recreational opportunities. This applies to the considerable number of reservoirs recommended for construction by Federal agencies in the Colorado River basin. The purchase of land sufficient only to meet the requirements for control of reservoir operation may exclude nearby lands highly useful for recreational development. Such lands may indeed be the key to complete development of important recreational opportunities. Under private ownership, such lands might be developed in a manner incompatible or even detrimental to public interests.

16. Public zoning of flood damage areas: The Federal flood control statutes should be amended to require that States and their local government units — as one of their contributions to a comprehensive river basin flood control program — shall provide effective zoning to prevent the further occupation of dangerous flood plain lands by industrial and residential installations. As a corollary of this requirement, the Federal

Government should have authority to acquire areas subject to frequent flood inundation and to use them for suitable purposes.

17. Basic data and research: There is need for much additional basic data for watershed management covering, in addition to cadastral and topographic surveys, such things as soils, precipitation, streamflow, sediment production and water quality. The research program in range management and reseeding, forest management, fire and insect control, forest and range resource and economic problems and forest products utilization needs strengthening and intensifying in the Colorado Basin to supply the basic needs for multiple-use management of the forest and range resource.

KEY MAP

LEGEND
- WATERSHED BOUNDARY
- STATE BOUNDARY LINE
- U.S. NUMBERED HIGHWAYS
- COUNTY SEATS
- STATE CAPITOL
- NATIONAL FOREST

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN, UTAH

FLOOD CONTROL SURVEY

COLORADO RIVER WATERSHED

SUBMITTED ____ APPROVED ____

COMPILED ____
TRACED RWP
CHECKED JAA

MAP NO 1

APPENDIX NO ____

SUMMARY

AREA NO.	SUB-BASIN AND STATION	AREA SQ. MI.	ANNUAL SEDIMENT A.F.	ANNUAL SEDIMENT A.F./SQ.MI.
A – F	Colorado River Above Hoover Dam	167,800	125,220	.75
A – E	Colorado River Above Grand Canyon	138,700	111,960	.81
A	Colorado River Above Cisco, Utah	24,100	12,050	.50
B	Green River Above Green River Utah	40,600	13,190	.32
C	San Juan River Above Bluff(nr) Utah	23,900	28,700	1.20
D	Little Colorado River Above Grandfalls	21,200	19,150	.90
E	Intervening Area	28,900	38,870	1.34
F	Hoover Dam to Grand Canyon	29,100	13,260	.46

Data for areas A, B, C & A-E inclusive from longtime suspended load records, area D from short time records, adjusted, area E interpolated and area A-F inclusive based on preliminary Lake Mead Reservoir survey, data adjusted.

--- BOUNDARY AREA COVERED BY PRIMARY STATION

--- BOUNDARY OF AREA ABOVE AND BELOW HOOVER DAM.

-- CLOSED BASIN

KEY MAP

LEGEND

WATERSHED BOUNDARY

STATE BOUNDARY LINE

U.S. NUMBERED HIGHWAYS

COUNTY SEATS

STATE CAPITOL

NATIONAL FOREST

ANNUAL SEDIMENT PRODUCTION ABOVE HOOVER DAM

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN, UTAH

FLOOD CONTROL SURVEY

COLORADO RIVER WATERSHED

SUBMITTED ____ APPROVED ____

COMPILED - J.A.A.
TRACED - R.W.P.
CHECKED - J.A.A.

MAP NO. 3

APPENDIX NO ____

4-28-50